



## **The Resistance of *Staphylococcus* Species to Different Antibiotics in Al-Kharj City**

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### **Author's contribution**

The sole author designed, analysed, interpreted and prepared the manuscript.

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### **ABSTRACT**

**Introduction:** Infections caused by *Staphylococcus* species can spread not only in hospitals but also in the community and in other healthcare institutions. These organisms were known for its capability to acquire resistance to various classes of antibiotics.

**Methods:** The antibiotic susceptibility and resistance rates of *S. aureus* strains isolated from numerous clinical samples at a public hospital in Al-kharj city were collected from the monthly antibiogram prepared by the laboratory department in the hospital.

**Results:** The bacterial culture results found that there were 450 *Staphylococcus* species; the majority of bacteria were *Staphylococcus aureus*. Some medications such as Vancomycin, Linezolid still very effective in treating *Staphylococcus* infections.

**Conclusion:** *S. aureus* infections were common in Alkharj city and the resistance is widespread for *staphylococci* species, mainly MRSA. To reduce the resistance rate antimicrobial stewardship programs should be implemented and antibiotic susceptibility should be monitored continuously.

**Keywords:** Resistance; *Staphylococcus*; antibiotics; Al-Kharj.

### **1. INTRODUCTION**

Infections caused by *Staphylococcus* species can spread not only in hospitals but also in the

community and in other healthcare institutions. Centers for Disease Control and Prevention (CDC) reported that in the United States, about 5% of the patients in U.S. hospitals carry

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*Methicillin Resistance Staphylococcus aureus* (MRSA) on their skin or in their nose. [1] Antibiotic-resistant strains of *S. aureus* results in infections that spread globally and reached epidemic proportions [2].

Despite the improvements in the field of antibacterial treatment, there are numerous difficulties in the management of *Staphylococcal* infections. In several states, there are some patients suffer from serious infections caused by *Staphylococcus* species that were resistance to multi-drugs. For example, there is an increasing spreading of *Vancomycin-Resistant Staphylococci* [3,4].

*Staphylococcus aureus* causes wide range of infections in community and in nosocomial settings. This organism is known for its capability to acquire resistance to various classes of antibiotics. The resistance is rapidly evolved through many mechanisms including the chromosomal mutation and the gene transfer [5]. In 2014, many parts of the world such as portions of Southeast Asia and the western pacific reported that more than 80% of the infections caused by *Staphylococcus aureus* having a MRSA phenotype [6]. CDC stated in a 2013 report that in the United States, MRSA was deemed a serious antibiotic resistance threat [7]. This development and spread of multi-drug resistant species such as MRSA strains resulted in significant morbidity and mortality rates [8].

*Staphylococcus epidermidis* is one of the etiologic agents that are most commonly lead to nosocomial infections. It is mainly related to infections in patients who are implanted with medical devices, such as orthopedic prostheses and prosthetic heart valves [9-12] *S. epidermidis* strains frequently resist against numerous classes of antibiotic such as Aminoglycosides, Cephalosporins, Tetracyclines, Macrolides, Penicillins and Fluoroquinolones [13-16].

The emergence and spread of antibiotic-resistant bacteria has serious consequences on the rate of morbidity and mortality and also on the stability of public health systems [17]. As a result, many strategies have been developed to diminish this serious impact on health systems such as developing programs for cleaning and disinfection, epidemiological surveillance of antimicrobial resistance and

developing antimicrobial stewardship programs [18,19].

The overall prevalence of *Staphylococcus* related infections including MRSA is relatively high in Saudi Arabia as shown in previous studies, [20-22] but there is a lacking in the data regarding the resistance rate in Al-kharj city. Therefore, this study aims to explore the resistance rate of *Staphylococcus* species to different antibiotics in Al-kharj city.

## 2. METHODOLOGY

The antibiotic susceptibility and resistance rates of *S. aureus* strains isolated from numerous clinical samples at a public hospital in Al-kharj city was collected from the monthly antibiogram prepared by the laboratory department in the hospital.

The isolation, identification and preparing of the cumulative susceptibility pattern for antimicrobial agents were completed using standard microbiological techniques in the laboratory. For initial screening gram stain, colony morphology and biochemical tests were done. The identification results of the etiological agents were checked by using automated procedures "Phoenix 100/BD Company". For the identification of bacteria from clinical samples, the lab of microbiology in the public hospital used antibiotic susceptibility Phoenix 100/BD company machine and after the identification of the organisms and knowing the susceptibility to various antimicrobial agents, the antibiogram could be prepared.

This retrospective study includes the bacterial cultures from the beginning of 2015 till the end of 2018 and excludes the cultures that were collected before this period and also included only *Staphylococcus* species and excluded other types of organisms. Moreover, the *staphylococcus* species that were found infrequently (less than 30 bacteria) were excluded.

The data was collected by the microbiologists in the lab using Microsoft Excel software after that the data were analyzed and the descriptive statistics were reported as frequency and percentage of different *Staphylococcus* species, in addition to percentage of susceptibility and resistance rate.

### 3. RESULTS

The bacterial culture results found that there were 450 *Staphylococcus* species in the 4 years. The majority were *Methicillin –sensitive Staphylococcus aureus* (69.11%) followed by *Methicillin-resistant Staphylococcus aureus* (21.33%). Table 1 shows the number and percentage of different *Staphylococcus* species.

Vancomycin, Linezolid, Nitrofurantoin, Daptomycin, Imipenem and Rifampin were the most effective medications for the treatment of *Staphylococcus aureus* with antibiotic susceptibility of 100% (resistance rate = 0%). Percentage of antibiotic resistance and susceptibility of *Staphylococcus aureus* are shown in Table 2.

Vancomycin, Linezolid, Daptomycin were the most effective medications for the treatment of

*Methicillin-resistant Staphylococcus aureus* with antibiotic susceptibility of 100% (resistance rate = 0%). Percentage of antibiotic resistance and susceptibility of *Methicillin-resistant Staphylococcus aureus* are shown in Table 3.

Vancomycin and Linezolid were the most effective medications for the treatment of *Staphylococcus epidermidis* with antibiotic susceptibility of 100% (resistance rate =0 %). Percentage of antibiotic resistance and susceptibility of *Staphylococcus epidermidis* are shown in Table 4.

The resistance of all of the *Staphylococcus* Species were not pandrug resistant nor extensively drug resistant and only *Methicillin-resistant Staphylococcus aureus* bacteria were Multidrug resistant. The type of resistance of *Staphylococcus species* is shown in Table 5.

**Table 1. The number and percentage of different *Staphylococcus* species**

	<i>Staphylococcus aureus</i>	<i>Staphylococcus epidermidis</i>	<i>Methicillin-resistant Staphylococcus aureus</i>
Number of <i>Staphylococcus</i> species	311	43	96
Percentage of <i>Staphylococcus</i> species	69.11	9.55	21.33

**Table 2. Percentage of antibiotic resistance and susceptibility of *Staphylococcus aureus***

Antibiotics	<i>Staphylococcus aureus</i>	
	Antibiotic susceptibility percentage	Antibiotic resistance percentage
Erythromycin	74.3	25.7
Penicillin	6.1	93.9
Trimethoprim/sulfamethoxazole	83.3	16.7
Vancomycin	100	0
Ampicillin	10.2	89.8
Ciprofloxacin	73.3	26.7
Gentamicin	87.4	12.6
Linezolid	100	0
Clindamycin	83.3	16.7
Nitrofurantoin	100	0
Oxacillin	73.3	26.7
Cefotaxime	98.7	1.3
Daptomycin	100	0
Teicoplanin	99.2	0.8
Moxifloxacin	98.3	1.7
Tetracycline	88.4	11.6
Imipenem	100	0
Amoxicillin/clavulanic acid	93.7	6.3
Mupirocin	97.4	2.6
Rifampicin	100	0

**Table 3. Percentage of antibiotic resistance and susceptibility of MRSA**

Antibiotics	<i>Methicillin-resistant Staphylococcus aureus</i>	
	Antibiotic susceptibility percentage	Antibiotic resistance percentage
Erythromycin	60	40
Penicillin	0	100
Trimethoprim/sulfamethoxazole	71.9	28.1
Vancomycin	100	0
Ampicillin	0	100
Ciprofloxacin	75	25
Gentamicin	80.2	19.8
Linezolid	100	0
Clindamycin	71.9	28.1
Nitrofurantoin	96.9	3.1
Oxacillin	0	100
Cefotaxime	0	100
Daptomycin	100	0
Teicoplanin	99	1
Moxifloxacin	96.9	3.1
Tetracycline	65.6	34.4
Imipenem	2.1	97.9
Cefoxitin	0	100
Amoxicillin/clavulanic acid	0	100
Mupirocin	94.8	5.2
Rifampicin	99	1

**Table 4. Percentage of antibiotic resistance and susceptibility of *Staphylococcus epidermidis***

Antibiotics	<i>Staphylococcus epidermidis</i>	
	Antibiotic susceptibility percentage	Antibiotic resistance percentage
Erythromycin	34.9	65.1
Penicillin	2.3	97.7
Trimethoprim/sulfamethoxazole	58.1	41.9
Vancomycin	100	0
Ciprofloxacin	48.8	51.2
Gentamicin	34.9	65.1
Linezolid	100	0
Clindamycin	55.8	44.2
Nitrofurantoin	69.8	30.2
Oxacillin	7	93
Tetracycline	79.1	20.9

#### 4. DISCUSSION

The results showed that *Staphylococcus* species were the most common gram positive bacteria specially *Staphylococcus aureus*. This result is similar to the result of Shibl AM et al who reported that by the reviewing of gram-positive isolates from twenty four hospitals in Saudi Arabia, *Staphylococcus aureus* was the most common species (62.3%) [22].

Regarding the treatment of methicillin sensitive *Staphylococcus aureus*, Vancomycin, Linezolid,

Nitrofurantoin, Daptomycin, Imipenem and Rifampin were the most effective medications for the treatment of *Staphylococcus aureus* with antibiotic susceptibility of 100% (resistance rate 0 %). Similarly, Bhatt CP et al found that the sensitivity of *Staphylococcus aureus* to vancomycin is 100%. There are other effective antibiotics such as Cefotaxime (resistance rate =1.3% only) and Teicoplanin (resistance rate = 0.8), Moxifloxacin (resistance rate =1.7%) and Amoxicillin/clavulanic acid (resistance rate = 6.3%) on the other hand, the least effective antibiotics were Penicillin

**Table 5. The type of resistance of *Staphylococcus* species**

<b>Bacteria</b>	<b>Multidrug resistant</b>	<b>Extensively drug resistant</b>	<b>Pandrug resistant</b>
<i>Staphylococcus aureus</i>	No	No	No
<i>Methicillin-resistant Staphylococcus aureus</i>	Yes	No	No
<i>Staphylococcus epidermidis</i>	No	No	No

(resistance rate = 93.9%) followed by Ampicillin (resistance rate = 89.8%). Similarly, Bhatt CP et al reported that All the *Staphylococcus* isolates were resistant to Penicillin G [23].

Vancomycin, Linezolid, Daptomycin were the most effective medications for the treatment of *Methicillin-resistant Staphylococcus aureus* with antibiotic susceptibility of 100% (resistance rate= 0%). Similarly, Edwin Zhang and Brent Burbridge reported that Vancomycin is the primary antibiotic of choice for the majority of nosocomial MRSA infections, but some prescribers recommend the addition of other effective antibiotics such as Rifampin, Aminoglycoside or Daptomycin to enhance the bactericidal activity [24]. Other effective antibiotics include Nitrofurantoin (resistance rate = 3.1%), Teicoplanin (resistance rate =1%), Moxifloxacin (resistance rate =3.1%), Mupirocin (5.2%) and Rifampin (resistance rate=1 %). Similar results were found by Udo E.E. and Boswihi S.S. who reported that some medications can be used for the treatment of MRSA infections such as Rifampin (the resistance rate = 0.6%) and Mupirocin (the resistance rate=5%). [25] Dardi C. Kaur and Sadhana S. Chate also reported a good efficacy of Vancomycin and Teicoplanin (resistance rate = 0%) but in contrast to our results the resistance rate for Moxifloxacin and Ciprofloxacin was 100% [26].

Some antibiotics should not be used for the treatment of *Methicillin Resistant Staphylococcus aureus* such as Penicillin, Ampicillin, Oxacillin, Cefotaxime, Cefoxitin, Augmentin (the resistance rate = 100%). Similarly, Dardi C. Kaur and Sadhana S. Chate reported that the resistance rate of MRSA to Oxacillin and Cefoxitin is 100%. [26].

For the treatment of *Staphylococcus epidermidis*, the most effective medications are Vancomycin and Linezolid with antibiotic susceptibility of 100 % (resistance rate= 0%). Moderate efficacy was found with Tetracycline (resistance rate = 20.9%) and Nitrofurantoin (resistance rate =30.2%).

The least effective antibiotics were Penicillin (resistance rate =97.7%) and Oxacillin (resistance rate=93 %). Similar results was found by Haque N et al who reported that the least effective drug for the treatment of *Staphylococcus epidermidis* were Penicillin and Oxacillin with resistance rate of 94 % and 56 %, respectively [27].

The resistance of all of the *Staphylococcus* Species were not pandrug resistant nor extensively drug resistant and only *Methicillin-resistant Staphylococcus aureus* bacteria were Multidrug resistant.

Multidrug resistant (MDR) was defined as acquired nonsusceptibility to at least one agent in three or more antimicrobial categories. Extensively drug resistant (XDR) was defined as nonsusceptibility to at least one agent in all but two or fewer antimicrobial categories (i.e., bacterial isolates remain susceptible to only one or two antimicrobial categories). Pandrug resistant (PDR) was defined as nonsusceptibility to all agents in all antimicrobial categories [28].

## 5. CONCLUSION

The results show that *S aureus* infections are common in Alkharj city and that the resistance is widespread for *staphylococci* species, mainly MRSA. Some antibiotics such as Vancomycin, Daptomycin and Linezolid are very effective for the treatment of *S. aureus* infections, especially for multidrug resistance species. To reduce the resistance rate and to treat infections appropriately, antimicrobial stewardship programs should be implemented and continuous monitoring for antibiotic susceptibility are necessary to give the appropriate antibiotics.

## DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of

knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

It is not applicable.

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## COMPETING INTERESTS

Author has declared that no competing interests exist.

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